

**Quarterly Status Report
for Project
"Enhancements to and Applications With the "Unified" Long-term PSC Database"**

Year 1, First Quarter, Period ending 31 March 2004

Principal Investigator: Michael Fromm
Computational Physics, Inc.

Co-investigators: Jerome Alfred
Computational Physics, Inc.

Collaborators: Richard Bevilacqua, NRL
Michelle Santee, JPL
Tony Strawa, NASA AMES

1. Introduction

This report summarizes the project team's activity during the period 1 January – 31 March, 2004. It consists of a project plan, which was completed during this period, and an indication of the completion status of each phase of the project.

The intention of the investigative team is to closely follow the statement of work documented in our proposal. For this reason the proposal may be referenced in this and upcoming status reports. This project got underway in this quarter. Our activity was to formulate a project plan and to engage in planning meetings with collaborators. The present project plan is produced below.

2. Project Plan for Enhancements to and Applications With the "Unified" Long-term PSC Database

Scope

We intend to use POAM II and III, SAM II, SAGE II and III, ILAS and ILAS II, and HALOE enhance and extend the Unified aerosol and PSC database.

Contract Start Date: 1 January 2004.

Contract End Date: 31 December 2006.

Reporting Requirements

- * Quarterly Progress Reports (three per year).
- * Annual Reports (includes 4th quarter activity and annual summary)

Definitions

Unified - This means that the logical and, where possible, physical elements of computer programs and supporting data sets used to perform detection will be used for all measurement instruments.

Reference background - The extinction or extinction profile that represents the typical conditions of non-cloudy atmospheres related to a particular measurement in space and time.

Issues

1. This effort is intended not only for our benefit but also the benefit of the interested user community. The success of this project is proportional to the level of acceptance by the user community. Since NASA is paying for this and we are delivering data per the statement of work, we need to involve potential users along the way to make sure we are developing something that will be useful and unique.

2. Address the question: "Just what will the science community want to get from our data and our attempt to detect clouds?" I.e. will it matter whether or not the observed enhancement is a PSC vs. any other geophysical aerosol enhancement feature, examples including the POAM III and SAGE II/III observations of the fascinating forest fire smoke clouds in several summers in the northern hemisphere, and detection of volcanic plumes. Our purest objective should be to identify all believable, non-random observations of aerosol enhancement. These should then be scaled and categorized by relating them to various background and temperature conditions. In this way we would be detecting "clouds" of all kinds, then attempting to refine the definition of the observation by invoking known ambient conditions.

3. Address the question: "Just what IS a PSC?" And the related question: "What would a PSC of very small size look like to POAM/SAM/SAGE?" And another question: "Can PSC extinctions be non-unique in relation to ambient aerosol extinction? I.e. what do we make of the occasional observation of elevated aerosol extinction inside the vortex that is insignificantly above the outside-vortex background? And what happens in the

wintertime atmosphere when there is a considerable volcanic aerosol load? Can in fact PSCs form and be masked by the ambient aerosol?" If we are going to say that ours is a PSC detection algorithm, we need to understand the answers to the above questions.

4. We know that from a hydrodynamic standpoint a PSC is composed of droplets or crystals caused by condensation, sublimation, or freezing of droplets. Recently published analyses by Strawa et al. [2002] show that multi-wavelength occultation measurements have the ability to discern PSC composition. Our work will expand the original Unified database to include, where possible, multiwavelength extinction measurements and indications of cloud-particle composition.

5. This long-term record (1979-) has some periods with no (or spotty) occultation-measurement coverage. There are also other periods that can be filled in, for instance in the Arctic winter of 1996/1997. During this break between POAM II and III, ILAS made a full season of measurements. Moreover, there are other periods that benefit from multiple instrument coverage. This includes 2002-present, which has SAGE III, SAGE II, POAM III, and ILAS II. The Unified database will be expanded to include all of these.

6. New retrieval versions are sometimes released. Sometimes these new version dictate an update to the Unified database. For example, the SAM II data are being updated with a new version. When that version is released, we will do a version comparison and it merited, will replace the SAM II Unified data.

Deliverables:

1. Documentation.
 - * General algorithm description
 - * Data and data relation definitions
 - * Database user guide
2. Data
 - * Reference background data set
 - * Cloud Detection database
 - * Meteorology database
 - * Unified cloud catalog

The documentation will be written in ASCII or other term-searchable format.

The Unified data are stored in IDL© save files. Extracts from these files will be other IDL files or ASCII listings, whichever is requested by the user. The deliverables will be made available via file transfer protocol or possibly CD-ROM.

Project Plan

1. Extending the Unified Database Beyond December 31, 2000

The present database terminates on December 31, 2000. At the present time POAM III is still in routine operation. SAGE III began operational data collection in March, 2002.

Extending the Unified database with POAM data will involve the two basic levels of data processing that have been developed for the existing database: calculating the statistical background aerosol dataset and then exercising the cloud detection algorithm. Because of the staggered availability of the POAM and MET data (for instance, the NCEP/REAN is available to us approximately 1-2 months before the current time), and because the background calculation is based on monthly statistical analysis, we envision adding to the Unified database in "batches." We propose to add to the Unified database on a quarterly basis, processing each quarter data that are current up to 3 months before the current time. When the quarterly processing is complete, the data will be made available on the world wide web and an announcement will be disseminated.

In addition to the quarterly processing, we also intend to operate a "rapid-turnaround" version of the PSC detection. It has been standard practice at NRL/CPI, since 1998, to monitor POAM extinction data and broadcast a "PSC Alert" to a substantial list of interested scientists. The rapid-turnaround results will be supplanted by the regular, quarterly Unified results when they become available.

ILAS II operated for approximately 7 months in 2003. These data, when validated and released, will be merged into the Unified database and processed through the Unified cloud-detection algorithm.

1.1 Filling in Unified Gaps

As mentioned above, there are gaps in the Unified data record. The earliest gap is between the SAM and POAM era. In the Arctic, the gap encompasses roughly the period 1990-1993. Because SAM II made southern hemispheric measurements fairly continuously through 1992, the gap here is shorter (approximately 1 year: 1993). During the SAM/POAM data gap UARS HALOE and CLAES went into operation. CLAES measurements in particular have been used for PSC studies, as reported by Massie et al. [1997], for example. Even though CLAES is an emission-based limb remote sensor, the retrievals of aerosol extinction with a vertical resolution of 2.5 km are still a natural input to the Unified algorithm. The CLAES data record is unique in one regard that will require special handling. The UARS yaw cycle (nominally a 36-day interval) is responsible for an intermittent record of polar sampling by CLAES. For this reason, we will need to alter the algorithm for calculating background extinctions. We envision calculating the background statistics from each hemispheric sampling interval instead of the usual monthly period. HALOE profiles of aerosol extinction are typically not measured at high latitudes in the winter half of the year, but like SAGE, there are occasions when HALOE does make such measurements and PSC observations [Hervig, 1999]. We have also found, in ad hoc inquiries, that HALOE profiles in the Arctic in summer have shown evidence of the smoke clouds detected by POAM and SAGE. Thus these data will be useful not only to fill in the SAM/POAM and POAM II/III gaps, but as an additional, contemporaneous measurement resource for the Unified database.

The second gap is between POAM II and III (November 1996 to April 1998). ILAS operated from November, 1996 until June, 1997. ILAS's measurement latitude is essentially identical to POAM, so the Arctic winter of 1996/97 was monitored in a manner consistent with POAM. Hayashida et al. [2000] reported on ILAS PSC observations in this season and showed it to be a period of extensive PSC formation, thus these data will be an important addition to the Unified database. The primary ILAS PSC-detection channel is at 780 nm. Even though it is not a 1 μm channel, the Unified algorithm will handle these data in a straightforward manner. It will not be possible to directly compare the background extinction data from ILAS (nor HALOE and CLAES) with those of 1 μm instruments, however the extinction enhancement data (expressed in the Unified database in terms of multiple standard deviations from the background) and PSC-detection results will be directly comparable. Because ILAS operated well into the 1997 austral fall, we will analyze the ILAS data to the end of its record and include them into the Unified database. PSCs have been shown by Fromm et al. [1997] to begin forming at POAM/ILAS latitudes in mid May, so ILAS will enable us to produce a record of the early season PSC observations in 1997.

1.2 Augmenting NCEP/REAN MET Data With ECMWF

We propose to add MET data from the ECMWF to the Unified database to provide a resource logically identical to the NCEP/REAN. This will entail calculating collocated profiles of temperature, potential vorticity, and geopotential, as well as collocated tropopause height (using the altitude of the 3 PVU surface). We will also use the Nash vortex edge algorithm to calculate a vortex edge data set from ECMWF. The only difference between our use of the NCEP/REAN and ECMWF data is that we will only use the NCEP/REAN for the temperature PSC threshold value. We will experiment with the two analyses to determine what if any difference they make on PSC yes/no based on the temperature screen values, but we do not envision providing two alternate PSC yes/no determinations based on each analysis's temperatures.

SAGE III will make temperature profile measurements. Having two MET analyses with which to compare SAGE temperature and derived tropopause height, all within one database, will give a unique capability and value to the Unified database.

1.3 Add Multi-wavelength Information

Of the solar occultation instruments that make up the bulk of the existing Unified database, only SAM II is a single-wavelength device. As the Unified database grows by insertion and addition of new measurements by ILAS, POAM III, SAGE III, and ILAS II, it will become more compelling to go beyond 1 μm extinctions as the only aerosol measurement of importance. Strawa et al. [2001] have developed an innovative algorithm for inferring PSC composition using multiple wavelength extinction data. In brief, the algorithm takes advantage of distinctive patterns formed (in x-y space) by pairing extinction enhancement (measurement/background) and extinction wavelength ratio (600nm/1000 nm) that are also produced by a microphysical model simulating liquid and solid particle growth. The Strawa et al. [2001] results (using POAM III data during SOLVE/THESEO) agreed

with DIAL lidar PSC inference in 7 of 8 coincident measurement events. We propose to refine, test, and use the Strawa et al. [2001] algorithm on all the instrument data sets for which there are several wavelengths at which extinction measurements are made. This effort will be most straightforward for POAM and SAGE, because of the similarity of the wavelengths used. However, we intend to extend the Strawa analysis to other instruments whose wavelength set is offset from POAM/SAGE. If success is achieved (i.e. satisfactory agreement between measurement and model calculations for particle growth patterns associated with composition) then we will include results in the Unified database. Presently we envision including the following additional data items: wavelength extinction ratio and a flag for composition. We currently conceive of assigning three categories: "liquid", "solid", and "uncertain" (or "mixed").

2. Applications With the Unified Database

2.1 Denitrification

Bevilacqua et al. [2001] performed an analysis of POAM III PSC observations and UKMO temperatures leading to an inference of denitrification during the SOLVE/THESEO PSC season on the order of 75%. These results were in close qualitative agreement with other estimates of denitrification based on measurements made specifically for the SOLVE/THESEO campaign. Because such campaigns are naturally episodic, and satellite monitoring of the polar realms has been nearly continuous for the Unified period, the Bevilacqua et al. [2001] method can be used to great effect for the entire Unified period and in both hemispheres. Briefly, the method involved a statistical approach whereby PSC-sighting probabilities were calculated for 2-K bins of temperature relative to T_{NAT} . Temporal changes in the PSC probability calculated in this way were the basis for the estimates of denitrification. Considering the relevance of this research, the utility of the approach, and the breadth of the Unified database, we propose to extend the Bevilacqua et al. [2001] technique to the full Unified database. This will be especially straightforward to adapt to other Arctic winters because it is not expected that complications due to significant dehydration will be present. Even though dehydration is a significant factor in the Antarctic [Nedoluha et al., 2000], we believe we can perform this analysis in the austral fall and early winter, from the onset of PSC observations (typically in May) until temperature and PSC observations suggest an onset of Type II clouds (which, according to our examination of the Antarctic Unified data, appears to occur between late June and mid July). Tabazadeh et al. [2000] found that in the Antarctic in 1992, appreciable denitrification preceded dehydration, and was in evidence in the second half of June, so we will expect to have sufficient PSC data to calculate estimates of denitrification in the Antarctic for most of the years in the Unified period.

For seasons of study for which multi-wavelength data are available, the denitrification study will incorporate the PSC composition information (described in section 3.2.4) to correlate denitrification patterns with relative proportions of solid (i.e. potential agents of denitrification) and liquid (i.e. non-denitrifying) PSC sightings.

2.2 Early-season PSC Onset Temperature

A curious, unpublished, recent finding with POAM II and III Arctic data is that there has been a real (albeit unexplained) change in the temperature at which PSCs start forming in the early days of the PSC season. In the POAM II winters of 1994/1995 and 1995/1996, PSCs began forming (typically in the second half of November in each of these seasons) at temperatures, with respect to NAT condensation, 3–4 K higher than in the POAM III winters of 1998/1999 and 1999/2000. Although it is possible that these findings were an artifact of errors in the temperature analysis, this is unlikely. We compared two analyses, UKMO and NCEP, and did not find a spurious trend that would give these intriguing results. Thus we consider this an interesting and relevant finding, one that might reveal inter-annual differences in precursor conditions that affect cloud formation. It will be worthwhile to explore the precursor meteorological conditions during the immediate pre-PSC time frame, PSC formation mechanisms (e.g. synoptic scale vs. mountain wave forcing), and also the impact of MET analysis on the temperatures. We will also assess the early-season PSC-formation temperatures in relation to other data at our disposal, including the reference aerosol extinction in the Unified database, and HNO_3 measurements from UARS Microwave Limb Sounder (MLS), which have been used extensively for PSC studies by, for example, Santee et al. [2002].

We contend that the Unified database is a natural resource for this type of study. It will be possible to perform an early-season PSC-onset temperature analysis in both hemispheres, over the entire Unified time span. Employing PSC/temperature relations analogous to those used by Bevilacqua et al. [2001] we will be able to infer any trends, cycles, or otherwise identifiable event-driven factors associated with changes in the likelihood of PSC formation at the beginning of the PSC season.

2.3 PSC Formation mechanisms

As shown in Figure 3, the Unified database is well suited to analyses that will shed light on forcing mechanisms. Teitelbaum et al. [2001] concluded that synoptic scale forcing was the primary Arctic PSC-forcing mechanism in 1994–1996, and Figure 3 indicates that this relation holds in a SAM II Arctic winter. However, Figure 3 also reveals that there may be many occasions where the PSC/synoptic forcing link is weak. We will embark on an exhaustive study to quantify the relative strength of various forcing factors. We will consider at least 3—synoptic scale dynamics as described by Teitelbaum et al. [2001], mountain wave (or other mesoscale dynamics) forcing, and diabatic cooling. We may be able to isolate individual cases (for instance based on proximity to a mountain range and an unusually high temperature) in which it is apparent that a PSC observation is related to small-scale processes. From such cases we can develop criteria to perform an organized search for PSCs that may be mountain-wave induced. It will also be our aim to assess the role of synoptic scale and mountain-wave forcing in the Antarctic in relation to diabatic cooling, which is known to be stronger and more enduring than in the Arctic. Preliminarily we envision starting our analysis in the Arctic, where it is expected that the role of broad-scale, seasonal cooling is a lesser factor, then compare the strength of the Arctic synoptic-

scale/PSC forcing link with that which is manifested in the Antarctic. This can and will be performed both statistically and on a case study level.

2.4 Ice PSC Climatology

Fromm et al. [1999] showed that a certain subset of POAM II PSC observations were what they termed "High Zmins" and showed that these were associated with likely Type II (ice) PSCs. The Unified algorithm includes a High Zmin flag for all profiles. We propose to examine the occurrence of High Zmins in both hemispheres to determine a climatology of Type II sighting probability. In the Arctic this is likely to be a climatology of episodic nature. For instance, we have already observed that since POAM III has monitored the Arctic (4 winters), there have been no Type II PSC sightings. In the POAM II time, there were multiple Type II episodes in each of 1994/1995 and 1995/1996. We expect, based on our experience with POAM data, to find a more regular occurrence of ice PSCs in the Antarctic, and will focus the study in two areas: 1. an analysis of date/location/temperature of Type II onset, and 2. an inference of dehydration amount using a technique analogous to that of Bevilacqua et al. [2001] for denitrification. This method will be evaluated by comparing the results with direct observations of dehydration using POAM III's water vapor observations [Nedoluha et al., 2000].

From the results of our study in the Antarctic we hope to learn if there are any inconsistencies between Type II formation temperatures in the northern versus southern hemisphere.

3. Summary

This project is progressing satisfactorily. Presently the project team is actively accomplishing identified tasks and communicating regularly the status of work in progress. The team expects to continue satisfactory progress in the upcoming months and is prepared to address any questions or requests that our project sponsor may have.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT 03/04		3. REPORT TYPE AND DATES COVERED Progress Report # 1- Quarterly Report
4. TITLE AND SUBTITLE Enhancements to and Applications with the "Unified" Long-term PSC Database			5. FUNDING NUMBERS NNH04C13C	
6. AUTHORS FROMM, Michael, ALFRED, Jerome, BEVILACQUA, Richard, SANTEE, Michelle, STRAWA, Tony				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Computational Physics, Inc. 8001 Braddock Rd. Suite 210 Springfield, VA 22151			8. PERFORMING ORGANIZATION REPORT NUMBER Quarterly Report # 1	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) NASA GSFC Greenbelt, MD 20771			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This report summarizes the project team's activity during the period 1 January – 31 March 2004. It consists of a project plan, which was completed during this period and an indication of the completion status of each phase of the project. The intention of the investigative team is to closely follow the statement of work documented in our proposal. For this reason, the proposal may be referenced in this and upcoming status reports. This project got underway in this quarter. Our activity was to formulate a project plan and to engage in planning meetings with collaborators.				
14. SUBJECT TERMS Enhancements to and Applications with the "Unified" Long-term PSC Database			15. NUMBER OF PAGES	
			16. PRICE CODE \$134,226.00	
17. SECURITY CLASSIFICATION OF REPORT unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT unclassified	20. LIMITATION OF ABSTRACT SAR	